SPECIFICATION, IMAGE PROCESSOR SPACECRAFT INTERFACE (IPSCI) BOARD

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REV	DESCRIPTION	DATE	APPROVED

1.0 SCOPE
This specification will detail the operation and control of the telemetry interface board for the image processor in the MDI experiment.

1.1 GLOSSARY
The following terms are used in this specification.

Block: A sub-division of a transfer. A transfer may be broken into smaller blocks for buffering.
Byte: 8 bits.
IPSCI: Image Processor Spacecraft Interface
DEP: Dedicated Experiment Processor
APU: Arithmetic Processing Unit (Image Processor)
Page: The 2304K byte partition of memory.
Transfer: The total number of data transfers in a DMA operation.

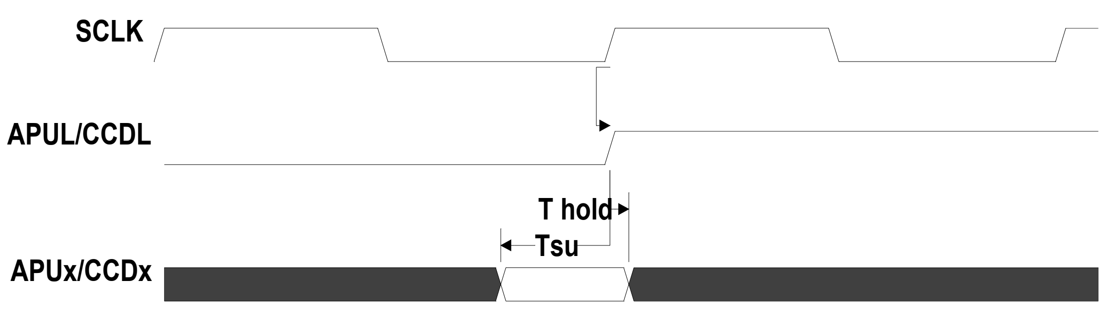
1.2 FUNCTIONAL DESCRIPTION
The IPSCI board interfaces the 16-bit data bus from the main memory of the image processor to the 163.84 Kbit serial data stream of the SOHO spacecraft. The IPSCI board also has the capabilities of compressing data, compacting data, or sending the data through raw. It will also format the data into packets and place a header at the beginning of each packet. The IPSCI board is controlled by two identical 8-bit command interfaces.

2.0 EXTERNAL INTERFACES
There are three primary interfaces to the IPSCI board, the command interface, the DMA interface and the spacecraft interface.

2.1 COMMAND INTERFACE
The command interface consists of two identical 8-bit command busses used to pass operational information to the IPSCI. There is also a latch input for each bus to clock the command word into a register. Commands are covered in detail below.

2.1.1 COMMANDING
There are two command interfaces to the IPSCI, one for the DEP and one for the APU. They are identical in operation. The IPSCI will always operate on the last command received after the current transfer frame is completed. In the event that both the APU and the DEP send a command the DEP will have priority. The timing for the command interface is shown in Fig. 1.

Fig. 1



T_{su} = 30 ns min
T_{hold} = 5 ns min

2.1.2 COMMAND WORD
The command word used to control the IPSCI is outlined in Table 1. Bit 0 is the LSB and bit 7 is the MSB.The first two bits define the operational mode of the IPSCI. Bit 3 is used for a two-page command.

This command option will allow the IPSCI to do two identical operations on two different pages of main memory by sending it only one command. If another command is received before the IPSCI has completed its entire operation, the new command will be stored and the processing defined by that command will start at the beginning of the next transfer frame. Bits 4 & 5 of the command word store the 2 LSBs of the first main memory page address to be sent and bits 6 & 7 define the second page to be sent.

TABLE 1

BIT0 BIT1	COMMAND BITS	00 = FILL MODE 01 = COMPRESSED MODE 10 = COMPACTED MODE 11 = RAW DATA
BIT2	NOT USED	
BIT3	1/2 PAGE MODES	0 = 1 PAGE MODE 1 = 2 PAGE MODE
BIT4 BIT5	PAGE ADDRESS, PAGE 0	FIRST PAGE IN 2 - PAGE OPERATION
BIT6 BIT7	PAGE ADDRESS, PAGE 1	SECOND PAGE IN 2 - PAGE OPERATION

2.2 DMA INTERFACE

The DMA interface sends commands to the DMA controller for main memory and receives data from main memory to be output to the spacecraft interface. Operation is defined in the specification for the DMA controller, document number MDI330018. The compression parameters K and N are contained in the first word received from memory in a DMA transfer as shown below with bit 0 the LSB and bit 15 the MSB.

bits 0-3	K bits 0-3
bits 4-7	N bits 0-3
bits 8-15	unused

2.3 SPACECRAFT INTERFACE

The spacecraft interface outputs the data packets processed in the IPSCI board to the spacecraft high-speed telemetry. This interface receives a 163.84 kHz data clock from the spacecraft and uses it to shift data out serially. See EID-A issue 1, rev. 3, section 3.3.8.2 for details on the spacecraft interface.

3.0 INTERNAL FUNCTIONS

The internal functions of the IPSCI consist of the data formatter and data processor to generate a fill pattern, compress data, compact data or return the data with no processing (raw data).

3.1 DATA FORMATTER

The data formatter formats the data into 1119 byte packets that include sync words, a transfer frame header and the MDI transfer frame. Formatting is detailed in Table 4 at the end of the document. The transfer frame and packet formats are identical to those used by the spacecraft. Further information on this format can be found in the CCSDS Packet Telemetry Blue Book (CCSDS 102.0-B-2). Data is sent out MSB first as specified in the EID. Note: Compressed data and compacted data are sent out LSB first. See paragraphs 3.3 and 3.4 for details.

3.1.1 TRANSFER FRAME PRIMARY HEADER

The transfer frame primary header consists of the first 10 bytes of the transfer frame. The sync words, frame ID, and frame data field status are all fixed values and don't changes from frame to frame. The master channel frame count and the virtual channel frame count are the lower 8 bits of the 14-bit sequence count output in the source packet header. This counter counts transfer frames and is reset only on power-up or through a system reset.

3.1.2 SOURCE PACKET HEADER

The source packet header consists of the next 6 bytes and contains the packet ID, sequence count and packet length. The packet ID and packet length are fixed values. The first 2 bits of the sequence count are the segmentation flags and are both set to a high level. The sequence count is a 14-bit counter that is reset on power-up and with a system reset. It is then incremented once every transfer frame.

3.1.3 SOURCE DATA FIELD

If there is no data to be processed, the source data field is filled with the hex value 37 (see par. 3.2). If there is data to be processed and an active command, the first 2 bits are the process ID. The process ID is the 2 command bits from the command interface that define the mode of the IPSCI. The next 22 bits of the source data field are the block address which is an input word counter. The counter is reset at the beginning of each new page of memory read out. The next byte contains the compression parameters K and N with N in the upper half of the byte and K in the lower half. The next 1099 bytes are source data. The first transfer frame sent after a new command will have a process ID of 11 and will output raw data from memory. This is so the CCD header contained in the first 256 words of memory is sent down uncompressed or uncompacted. Subsequent transfer frames will have the process ID and data field associated with that command. The data fields for the different process IDs are covered in the following paragraphs.

3.2 FILL MODE

The IPSCI will go into fill mode whenever there is no data processing to be performed. The IPSCI will enter fill mode on power up or after a system reset. When the data processing has been completed and there are no more active commands in the APU or CCD command buffers, the IPSCI will enter fill mode at the beginning of the next frame. In fill mode, the entire data field is filled with a hex 37, including the block address and compression parameter field.

3.3 DATA COMPRESSION

The data compression uses adjacent word differencing encoded with a Rice type algorithm with fixed compression parameters K and N. The K parameter specifies the number of data bits returned without compression with K + 1 = the number of bits including the sign bit, while the N parameter specifies the unsigned length of the valid data with N = the number of data bits. K may range in value from 1 to 6 (2 to 7 bits including the sign bit), and N from 8 to 14.

3.3.1 OPERATION

The difference passed to the Rice fundamental sequence circuit is a signed magnitude value with:

$$\mathrm{DIFF} = \mathrm{VAL}_n - \mathrm{VAL}_{n+1}$$

The sign is placed in the least significant bit with a 1 being negative. When two successive values are equal the difference will be zero and the sign bit will be indeterminate. The sign bit plus the K least significant bits are then returned uncompressed. The remaining difference is then encoded with a Rice type fundamental sequence as shown in Table 2. Saturation occurs when the remaining difference is greater than 7. When the fundamental sequence circuit is saturated, the sign bit plus the K bits are transmitted, then the fundamental sequence for saturation and then the remaining N - K bits of the difference. Because there is a sign bit generated with data compression the total number of bits sent will be N + 1.

TABLE 2

DIFFERENCE	FUNDAMENTAL SEQUENCE
0	1
1	01
2	001
3	0001
4	00001
5	000001
6	0000001
7	00000001
SATURATION	000000001(DAT) where DAT is remainder of raw difference

3.3.2 DATA FIELD
The data field for data compression will be formatted as shown below in Table 3.

TABLE 3

WORD	DESCRIPTION
21	INITIAL VALUE, HIGH BYTE
22	INITIAL VALUE, LOW BYTE
23	COMPRESSED DATA
:	:
:	:
1117	COMPRESSED DATA
1118	FINAL VALUE, HIGH BYTE
1119	FINAL VALUE, LOW BYTE

The initial value in a frame will not be the same word as the final value of the previous frame. The compressed data will be transmitted in the following manner:

$K_1, FS_1, K_2, FS_2, ... K_n, FS_n$

where FS is the fundamental sequence and K is the K bits stripped off after the difference operation. The example below uses K = 2 and N = 9.

Word	Data	Diff	Bin	Sign	K bits	F.S.
1	77					
		14	1110	0	100	0001
2	63					
		-18	10010	1	101	00001
3	81					
		11	1011	0	110	001
4	70					
		-47	101111	1	111	000000001 + remainder of difference
5	117					

The K bits and N - K bits sent out for saturation are sent out LSB first while the fundamental sequence and initial and final values are returned MSB first, so the bit stream will be as follows:

time >
001 0001 101 00001 011 001 111 000000001 1101000. . . . . . .
K_1 FS_1 K_2 FS_2 K_3 FS_3 K_4 FS_4 remaining diff

Where there are bits left over between the final bit of compressed data and the final value, they will be filled with zeroes. To insure that a data word is not truncated, there will be no more processing after byte 1115 of the transfer frame. If there is still a word being processed after byte 1115, it will be completed and the remainder of the bytes up to 1118 will be filled with zeroes. Then the operand of the last differencing operation will be output as the final value. When the final block of data from memory has been processed, the formatter will fill the remainder of the frame with zeroes and then output the final value in the last two bytes.

3.4 DATA COMPACTION
In data compaction mode K is set equal to N with the data having a quantization value of N bits. In compaction mode N may range from 8 to 15. The K and N bits are contained in the first word read from memory just as for compression (see par. 2.2). The data is sent out in continuous N-bit words filling the 8792 bit data field in a transfer frame, with the least- significant bits of each word sent first. Only whole words are sent and any spare bits left in the transfer frame data field are filled with zeroes. After the final value in memory is sent, any remaining bits in that byte will be filled with zeroes and subsequent bytes in the transfer frame filled with the zeroes. Note: Only the data (words 21 - 1119) are sent LSB first. Header data, process ID, block address and compression parameters are sent MSB first as per the EID.

3.5 RAW DATA
In raw data mode the contents of memory are sent to the spacecraft interface unprocessed. The compression parameter field containing the K and N values will be a "don't care" and may be set to any value. Because there are an odd number of 8-bit data bytes in a transfer frame, the final value in a transfer frame will be zero. After memory has been emptied, the remainder of the transfer frame will be filled with the last value remaining in the FIFO read buffer with the last byte of the transfer frame a zero. Data is returned MSB first as specified in the EID.

TABLE 4

BYTE	DESCRIPTION	VALUE							
	TRANSFER FRAME PRIMARY HEADER								
1	SYNC MARK	3				5			
2	SYNC MARK	2				E			
3	SYNC MARK	F				8			
4	SYNC MARK	5				3			
	FRAME ID								
5	VER # = 0	0	0						
5	SPACECRAFT ID = hex 015	0	1	0	0	0	0	0	1
6	SPACECRAFT ID (cont)			0	1	1	0	1	
6	VIRTUAL CHANNEL ID = 5								0
6	OPER. CONTROL FLAG								
7	MASTER CHANNEL FRAME COUNT	8 - BIT COUNTER							
8	VIRTUAL CHANNEL FRAME COUNT	8 - BIT COUNTER							
	FRAME DATA FIELD STATUS								
9	SECONDARY HEADER FLAG = NONE	0							
9	SYNC FLAG = SYNCRONOUS		0						
9	PACKET ORDER FLAG			0					
9	SEGMENT LENGTH ID = UNSEGMENTED				1	1			
9	FIRST HEADER POINTER	0	0	0	0	0	0	0	0
10	FIRST HEADER POINTER (cont.)						0	0	0
	MDI PACKET HEADER								
	MDI HIGH-RATE DATA IDENTIFIER = 80C4								
11	VERSION # = 2	1	0	0					
11	TYPE = TELEMETRY				0				
11	SECONDARY HEADER FLAG = NONE					0			
11	APPLICATION PROCESS ID = 0C4	1	1	0	0	0	0	0	0
12	APPLICATION PROCESS ID (cont.)	1	1	-	-	-	1	0	0
13	SEGMENTATION FLAGS						-	-	-
13	SOURCE SEQUENCE COUNT	-	-	14 - BIT					
14	SOURCE SEQUENCE COUNT (cont.)			COUNTER					
15	PACKET LENGTH	0				4			
16	PACKET LENGTH (cont.)	4				E			
	SOURCE DATA FIELD								
17	PROCESS ID	P	P						
17	BLOCK ADDRESS	-	-	22 - BIT					
18	BLOCK ADDRESS (cont.)			COUNTER					
19	BLOCK ADDRESS (cont.)								
20	COMPRESSION PARAMETERS	N				K			
21	DATA								
:	:								
:	:								
1119	DATA								